

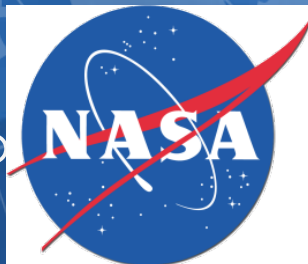
Using AIRS observations to forecast Asian pollution and stratospheric intrusion events in western U.S. surface air

Meiyun Lin

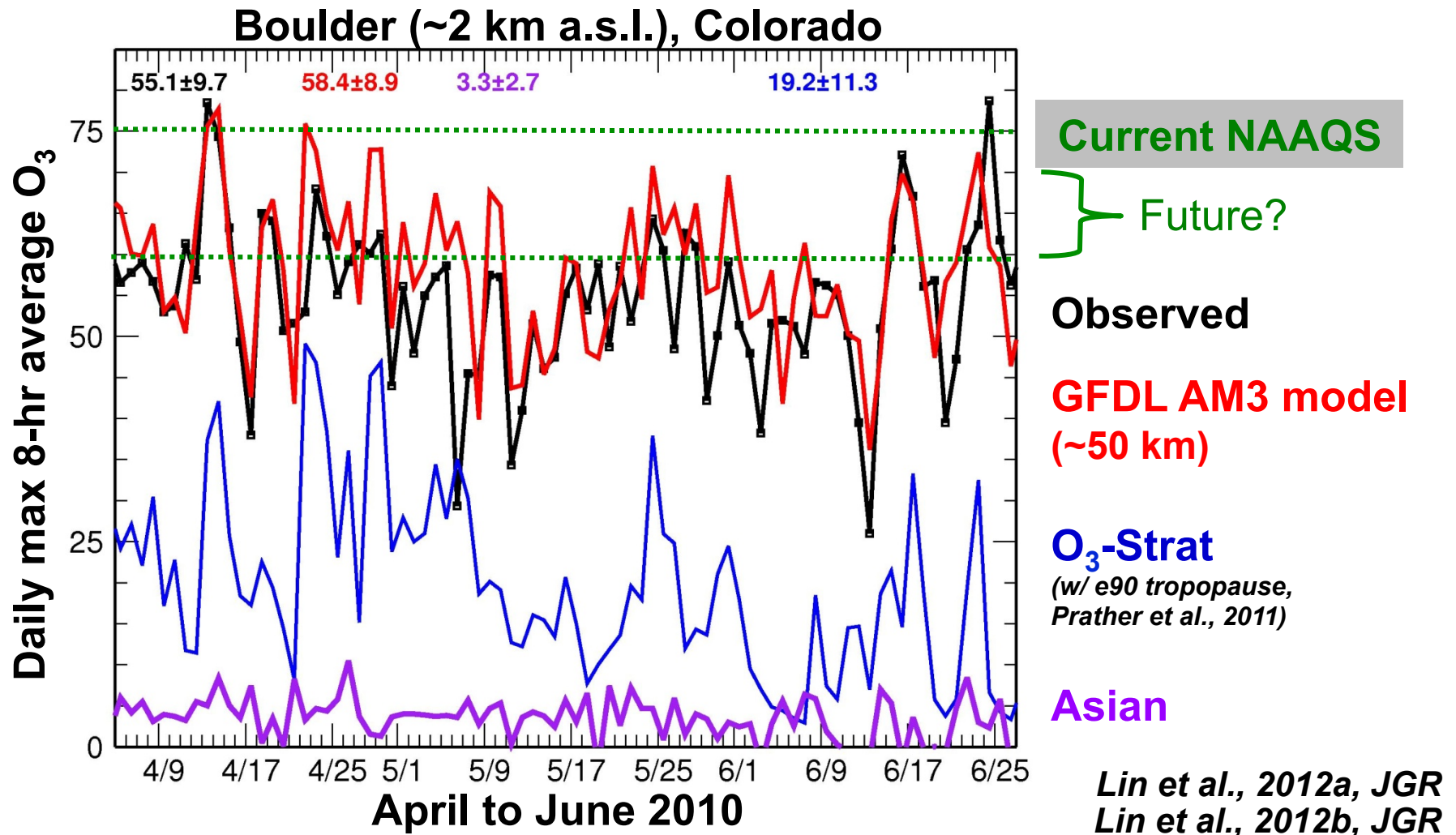
Princeton University & NOAA GFDL

AIRS collaborators: Juying X. Warner, Laura L. Pan

Others: A. M. Fiore, L. W. Horowitz, O. R. Cooper, A. O. Langford

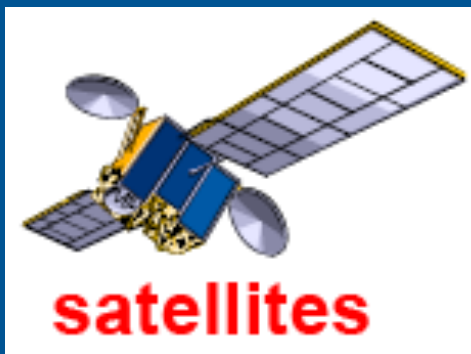


Asian and stratospheric influences on high-O₃ events in western U.S. surface air

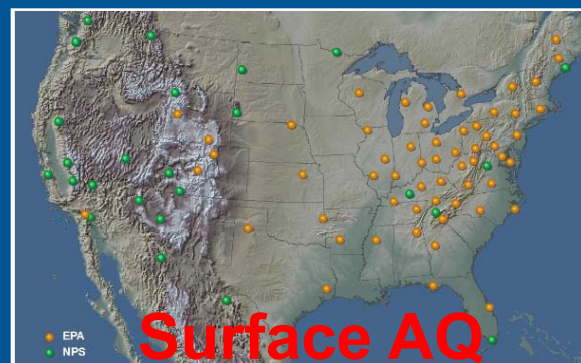


The policy challenges:

- 1) An ever-tightening ozone NAAQS
- 2) Screening of “exceptional events”
- 3) Developing forecasting tools



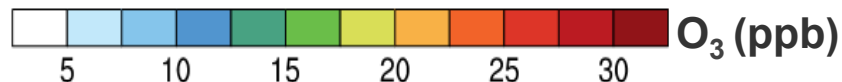
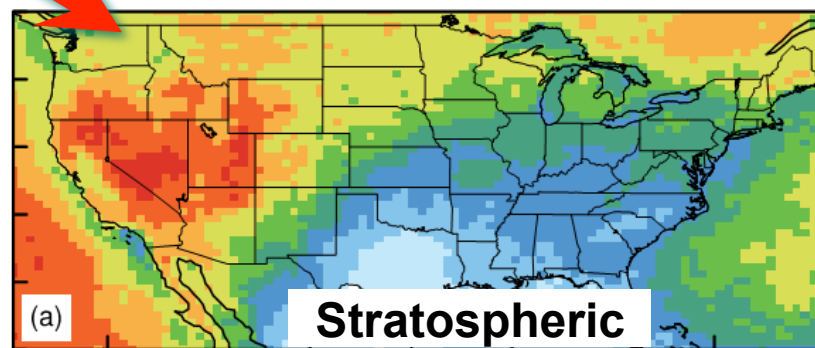
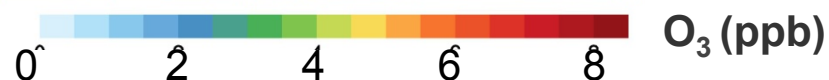
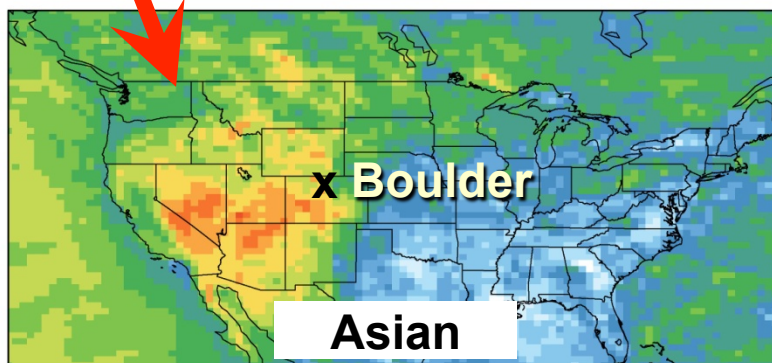
Space-based indicators of daily-to-yearly variability in background ozone



AIRS CO and O₃ products (V5.2):

- Global coverage obtained twice daily → Process studies of chemical evolution
- 2002-present (incl. several ENSO cycles) → Examination of yearly variability

[Aumann et al., 2003; Susskind et al., 2003; Pan et al., 2007; McMillan et al., 2005, 2011; Warner et al., 2007, 2010]



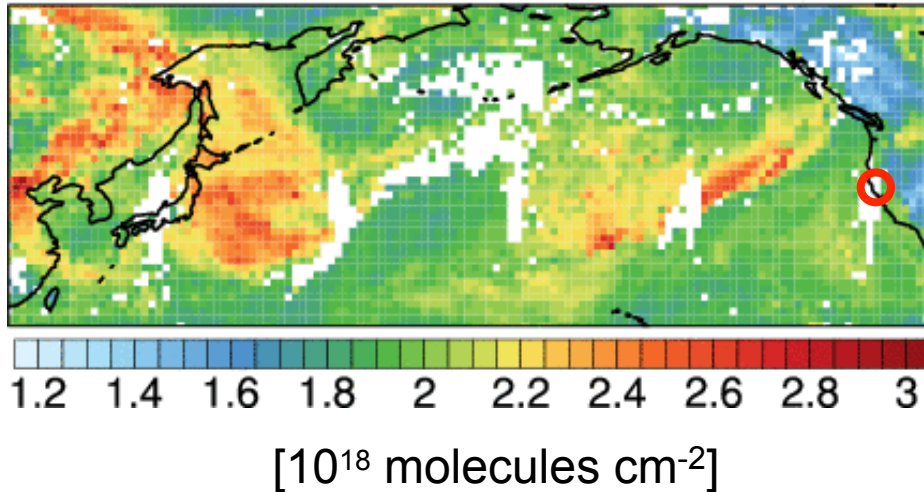
Mean Asian and stratospheric contributions to U.S. surface O₃ in spring
Estimated by the GFDL AM3 model at ~50x50 km² resolution

Trans-Pacific Asian pollution plumes

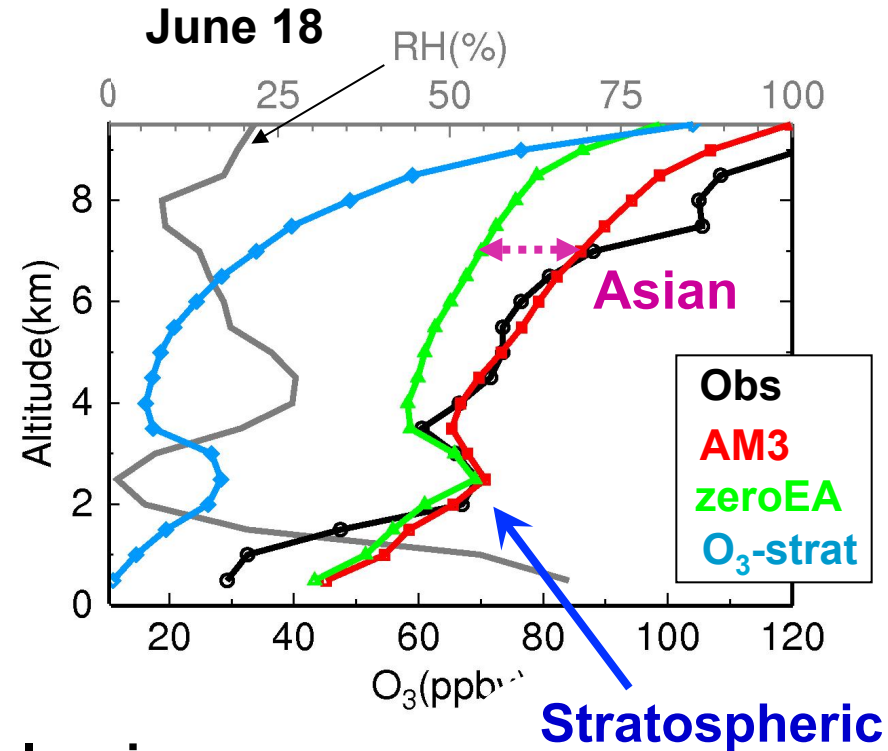
The view from satellites

(AIRS CO columns, V5.2, Level 3)

20100612



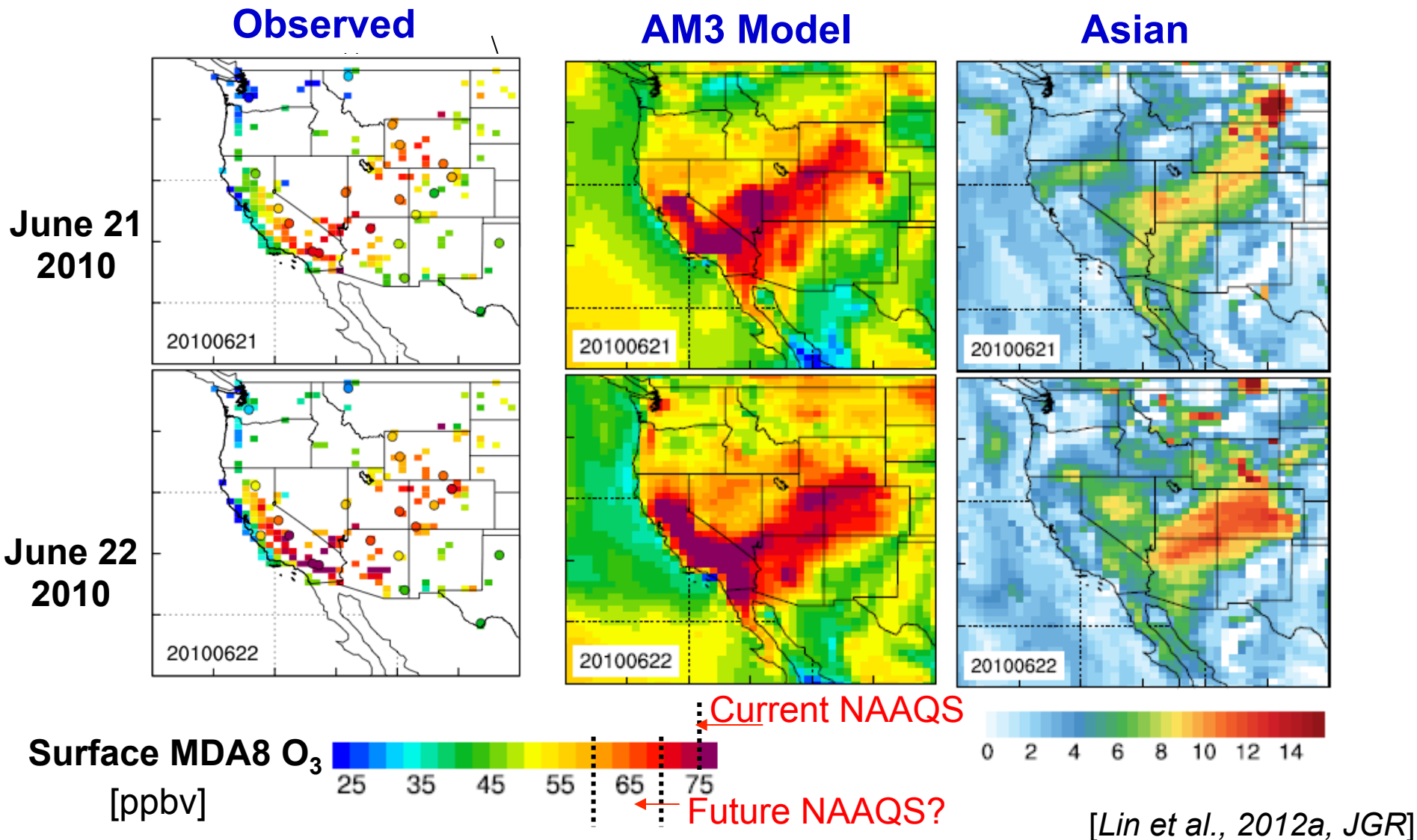
Point Reyes Sonde, CA



→ GFDL AM3 model captures the interleaving structure of **stratospheric** (2-4 km) and **Asian** ozone (4-10 km)

→ How important is Asian influence in surface air?

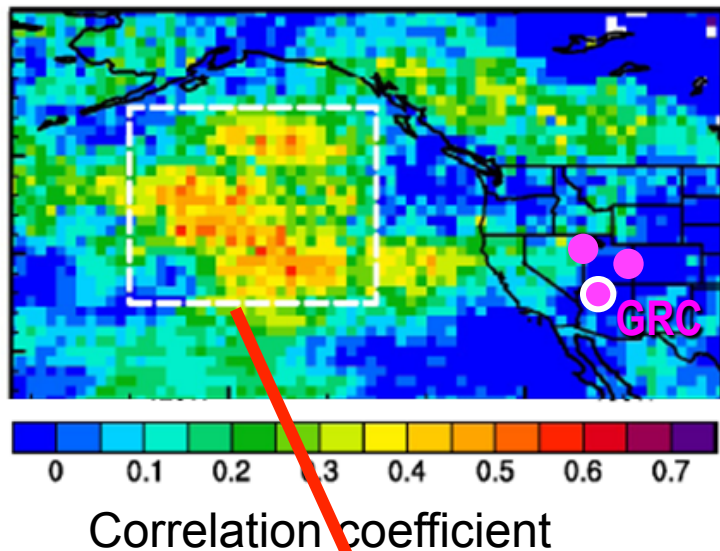
Asian pollution contribution to high-O₃ episodes



- Asian influence may confound efforts to attain tighter standards
- Developing forecasting tools from AIRS daily CO products?

Towards a predictive relationship: Correlations of daily AIRS CO and Asian influence on WUS surface ozone

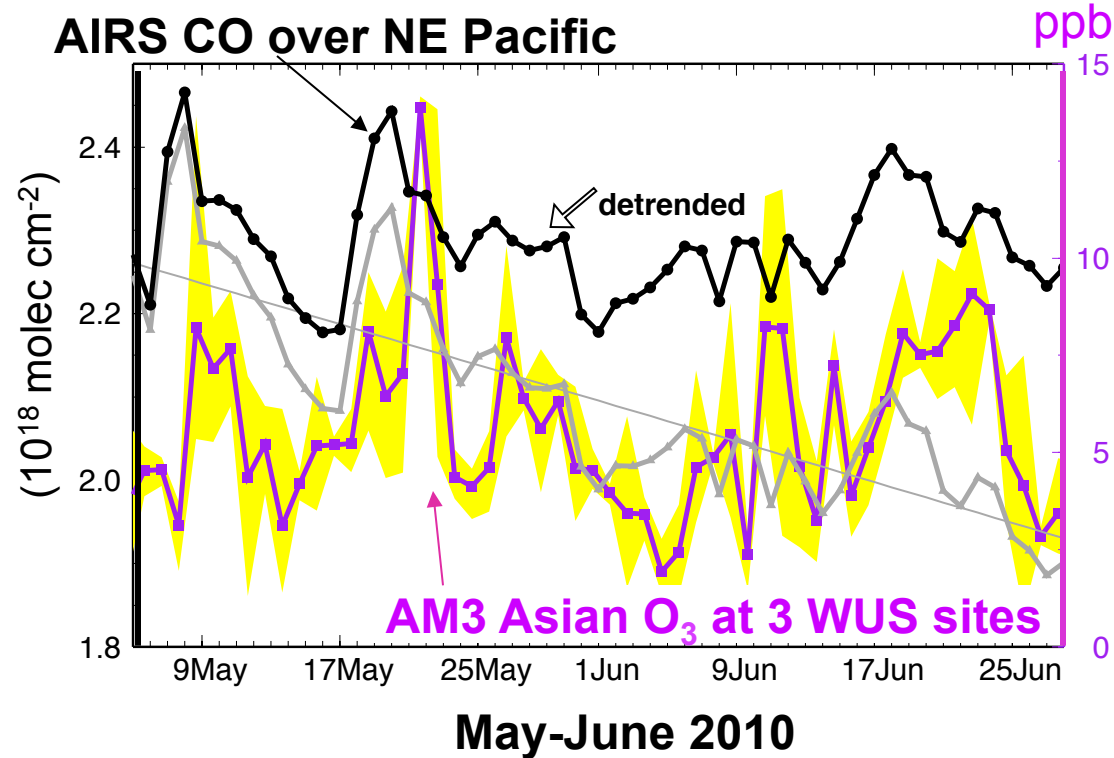
Correlation of Asian O_3 at Grand Canyon NP with AIRS CO columns
2 days prior in May-June 2010



Enhancements in AIRS CO

→ Advanced warning of Asian impacts on surface O_3 episodes in WUS?

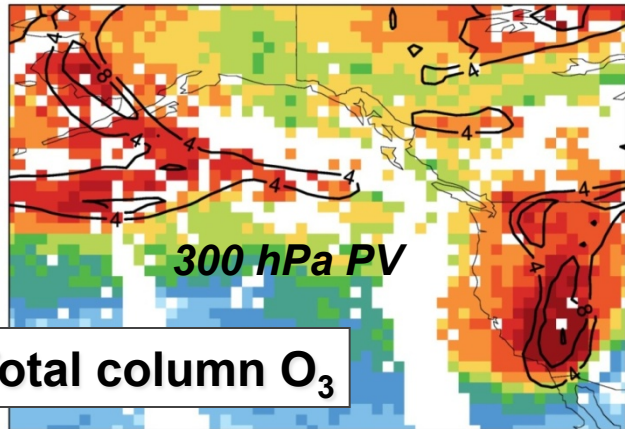
AIRS CO over NE Pacific



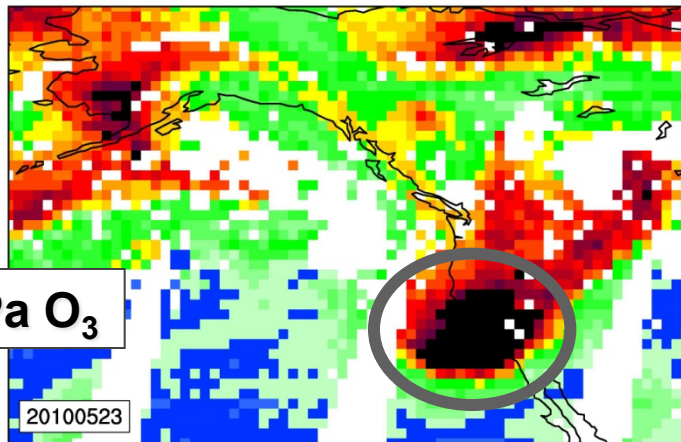
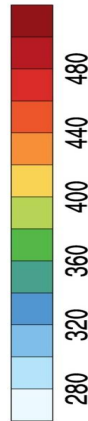
Lin, et al., 2012a, JGR (AGU Editors' Highlight, Featured in Nature News, ScienceShot in Science Magazine, and NY Times Green Blog)

An unusually large tropopause fold over Southern California (May 23, 2010)

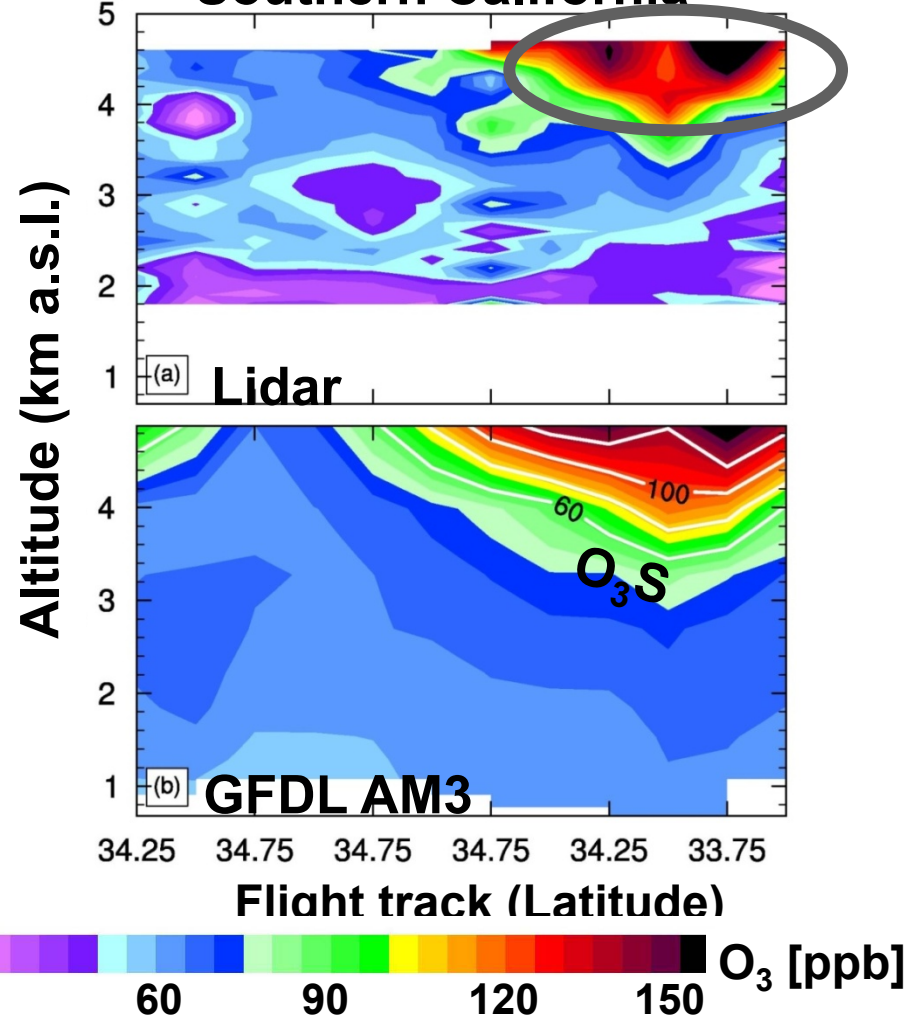
AIRS Ascending



DU



Southern California

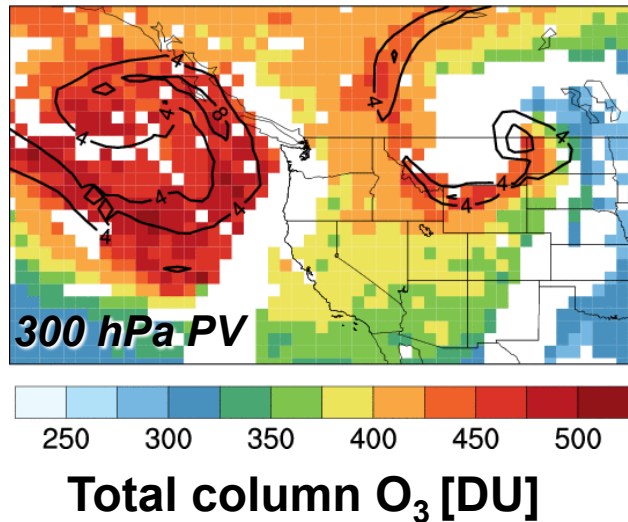


AIRS O₃ retrievals capture consistent dynamic features with PV, model and lidar measurements [see also Pan et al., 2007; Pittman et al., 2009; Wei et al., 2010]

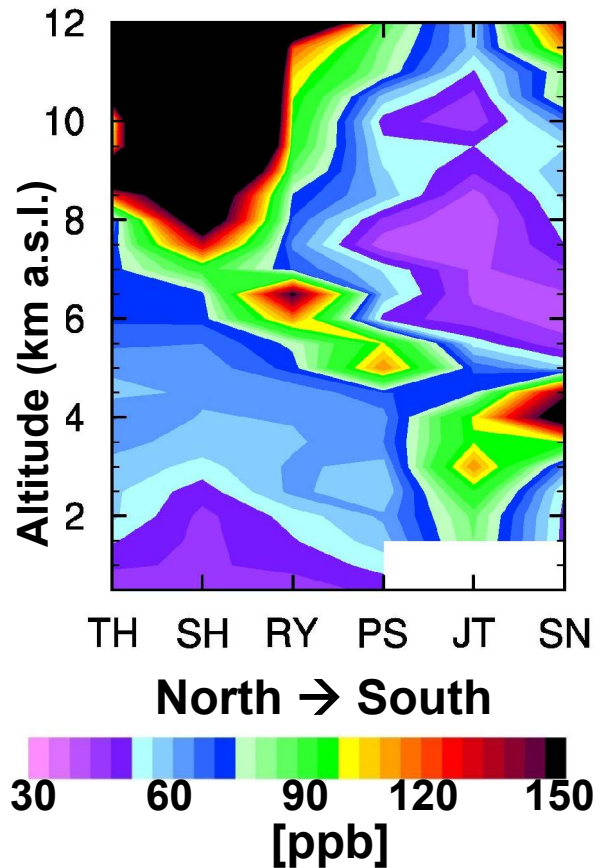
AIRS O₃ retrievals capture upper dynamics conducive to deep stratospheric intrusions over the western U.S.

AIRS, May 25-29

2010.05.25T01:30am

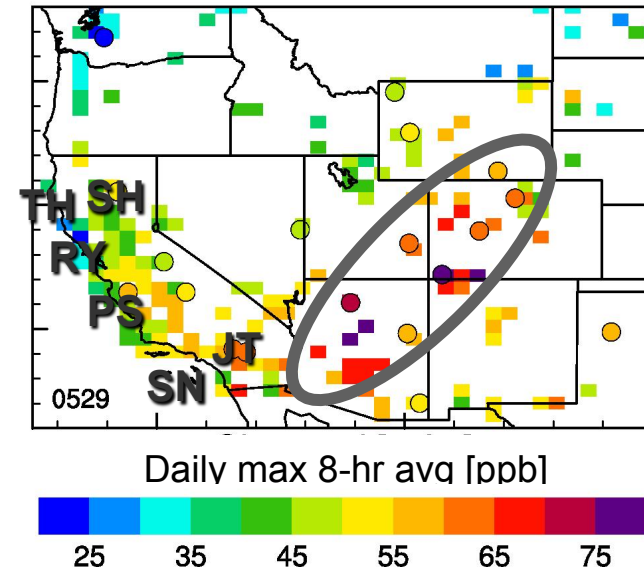


Sonde O₃, May 28



Lin, et al., 2012b, JGR

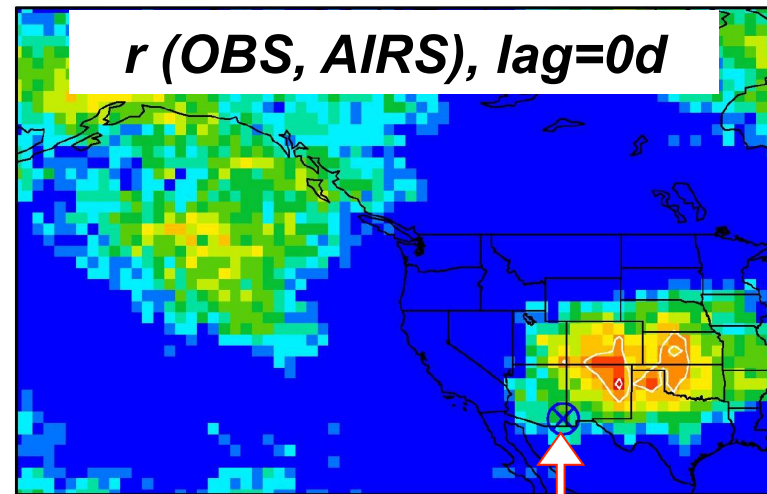
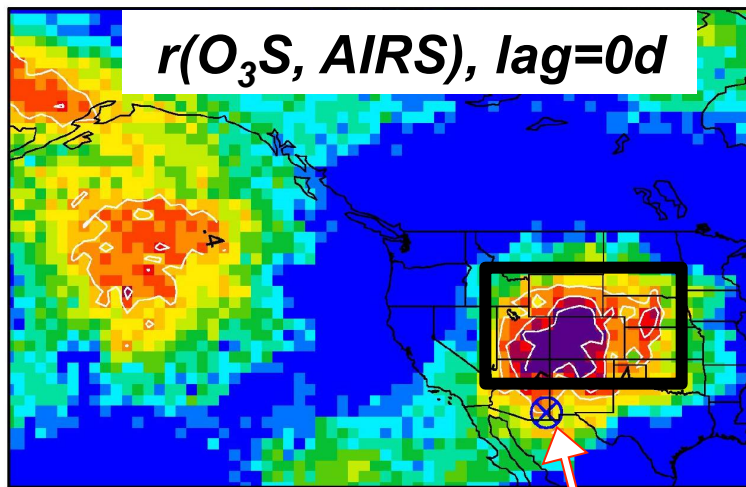
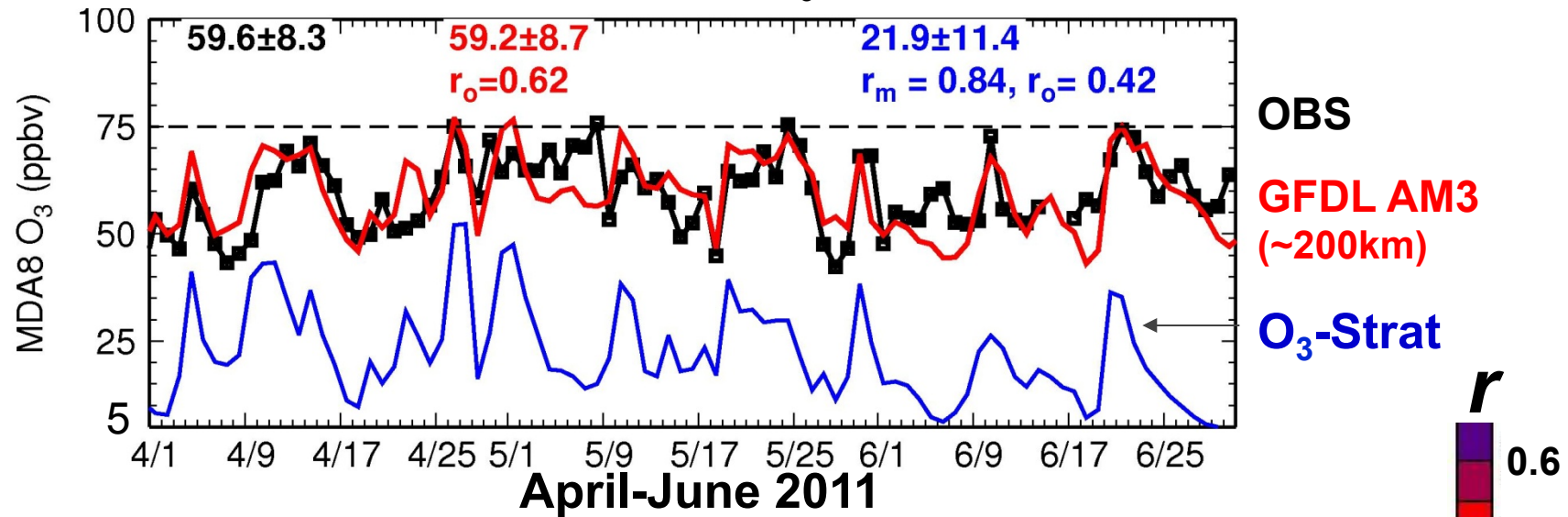
Surface O₃, May 29



Western U.S. is prone to deep intrusions
→ Co-varying enhancements in UT/LS, lower trop, and surface O₃

Towards a predictive relationship: Correlations of daily AIRS UT/LS ozone and surface ozone

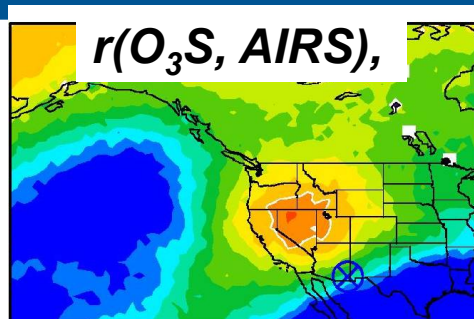
Daily max 8-hr average surface O_3 at Chiricahua NM, AZ



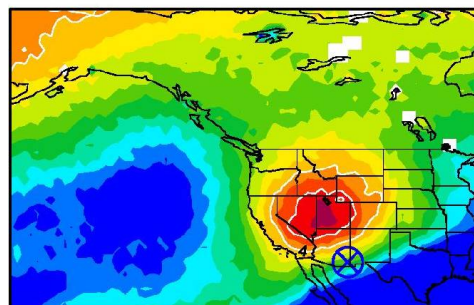
Correlation coefficient of AM3 O_3S and observed O_3 at CHA surface site, respectively, with **AIRS 300 hPa O_3** at each $1^\circ \times 1^\circ$ grid using daily datasets from April-May in 2011

Forecasting surface destinations of transported O_3 -strat

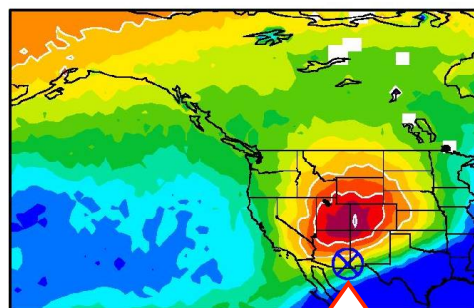
Lag = 3d



Lag = 2d



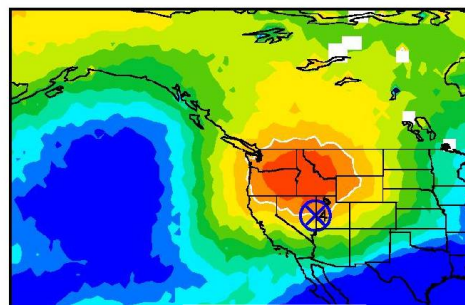
Lag = 1d



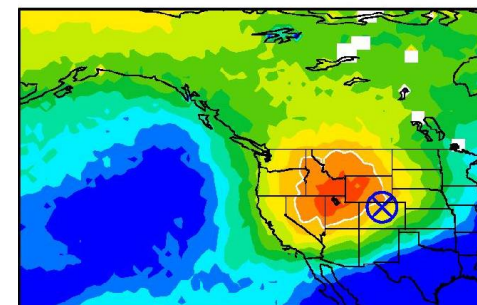
Chiricahua NM, AZ

Using daily datasets
from April-June, 2003-2011

Developing regional indicators for
different receptor sites?



Great Basin NP, NV



Rocky Mtn NP, CO

→ Stronger potential for accurate prediction in ~1 day as to where the intrusion will reach the surface

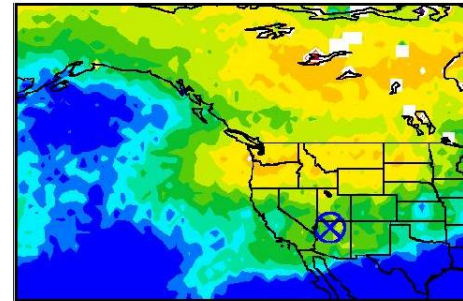
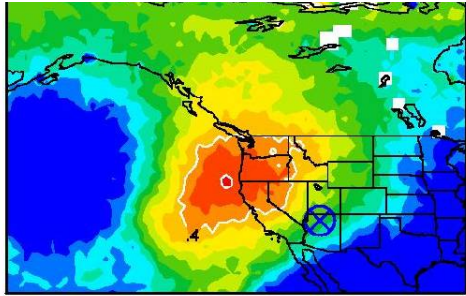
→ AIRS O_3 variability $\sim 5^\circ \times 5^\circ$ NW of a receptor site indicates incoming intrusions

The spatial pattern of correlations varies interannually: Links to ENSO in day-to-day progression

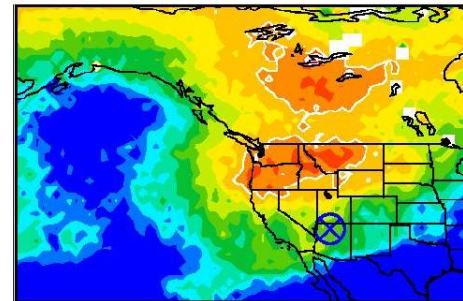
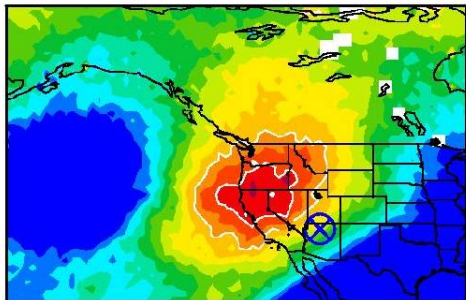
El Niño years
(2003, 2006, 2010)

La Niña years
(2008, 2011)

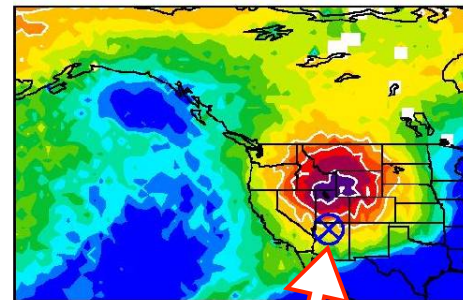
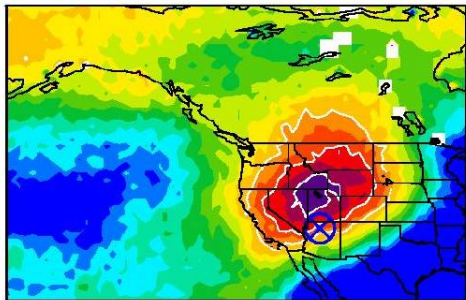
Lag = 3d



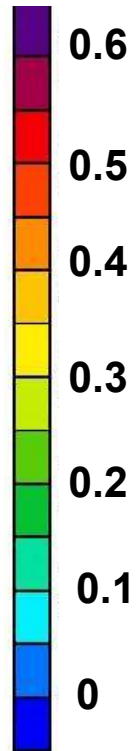
Lag = 2d



Lag = 0d



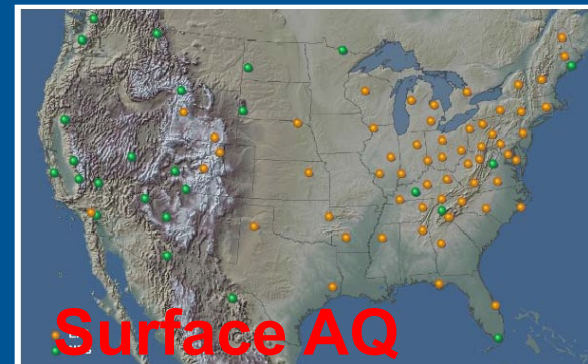
r



Correlation coefficient of **AM3** surface O₃S at **Grand Canyon NP** with **AIRS** total O₃ at each 1°x1° grid, 0-3 days prior using datasets from April-June



Space-based indicators of daily-to-yearly variability in transported “background”



Insights to processes controlling Western U.S. Air Quality:

- 1) AIRS CO over NE Pacific indicates potential for Asian influence
- 2) AIRS O₃ over WUS indicates potential for stratospheric influence

Potential AQ Applications:

- 1) Public health alerts
- 2) Identify exceptional events
- 3) Chemical data assimilation

Moving Forward:

- 1) Towards a quantitative relationship, e.g. Δ O₃ variability?
- 2) Exploration of other products, e.g. Aura (OMI/MLS), AIRS V6, IASI?

Thank you! (Meiyun.Lin@noaa.gov)

Additional slides for Q&A

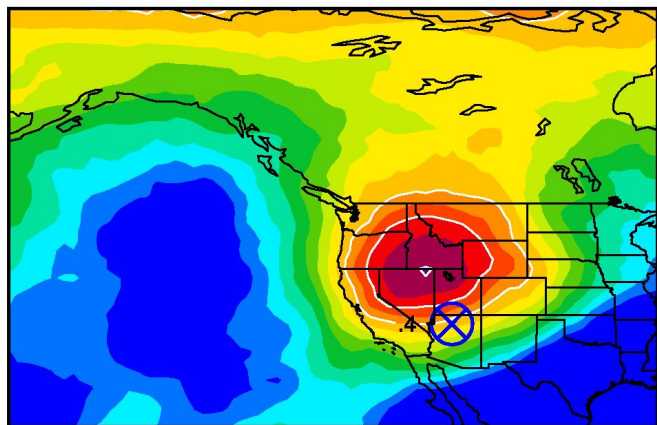
For some results presented, see also:

Lin, M., et al. (2012), Transport of Asian ozone pollution into surface air over the western United States in spring, *J. Geophys. Res.*, *117*, D00V07, doi: 10.1029/2011JD016961

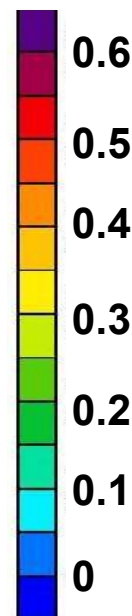
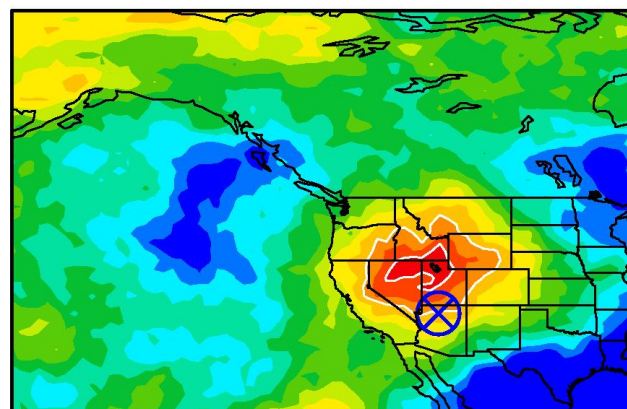
Lin, M., A. M. Fiore, O. R. Cooper, L. W. Horowitz, A. O. Langford, H. Levy II, B. J. Johnson, V. Naik, S. J. Oltmans, and C. J. Senff (2012), Springtime high surface ozone events over the western United States: Quantifying the role of stratospheric intrusions, *J. Geophys. Res.*, *117*, D00V22, doi: 10.1029/2012JD018151.

Correlations of daily OMI ozone and surface ozone

$r(\text{surface O}_3\text{S, OMI total column O}_3)$



$r(\text{surface O}_3\text{S, OMI } \sim 250\text{-}350\text{hPa O}_3)$



Correlation coefficient of AM3 surface O_3S at Grand Canyon NP with **OMI** data on the previous day using daily datasets from April-June, 2005-2008

Potential AQ Applications:

- ◆ Screening of “exceptional events”...combined with suborbital observations
- ◆ Advanced warning of regional high O_3 -Strat events with a lead time of $\sim 1\text{-}3$ days (more skill in 1 day)
- Qualitatively promising ...ongoing work for a quantitative relationship (ΔO_3)
- Utility of other Aura ozone products, e.g. MLS and TES?

For discussion, please contact Meiyun.Lin@noaa.gov